A BRIEF DESCRIPTION OF PET/MR

PET/MR is an emerging imaging modality that allows clinicians and researchers to examine the human body at both the anatomic and molecular level. The latest iteration in PET detector technology coupled with a 3T MRI scanner has converted into a hybrid modality with statistically enhanced TOF PET and superior spatial resolution. Two separate examinations can now be acquired in one simultaneous imaging session.

The simultaneous collection of PET/MR data provides diagnostic images that display accurate tracer biodistribution along with robust soft tissue characteristics, the ability to employ tissue weighting techniques, and a decreased radiation dose in specific populations. Current foci for PET/MR include various cyclotron produced radionuclide ligands that specifically probe new depths of neurology, oncology, and immunology.

HOW IT IS PERFORMED

Latest generation PET/CT machines use low dose scout CT scans for topogram, PET bed planning, and quantitative PET SUV-correction values. Instead of ionizing radiation, PET/MR uses ultra-fast MRI Dixon sequences (MRAC’s) to separate and segment anatomy for PET attenuation correction (AC) maps. Water, Fat, In Phase, and Out of Phase Dixon MRAC’s are acquired in real time at each PET bed location.

After MRAC generation and SAR scout measurements, 3 plane localizer sequences are used to capture anatomical patient data needed for PET planning. PET tracer info, reconstruction parameters, anatomical boundaries needed for correct AC map statistics, as well as the MRI sequences used for anatomical reference are planned and prescribed. All MRI sequences are linked to the PET bed acquisition at iso-center in neuro imaging. Whole body imaging uses multiple PET beds, each corresponding bed with their own MRI sequences assigned. Similar sequences with linear parameters acquired in each PET bed can be fused together for contiguous viewing.

WHO WILL INTERACT WITH THE PATIENT, ROLES EACH PERSON PLAYS

(technologist, Radiologist, NM physician, front desk staff)

A patient who will be undergoing a PET/MR procedure, may interact with various staff which include PET/MR imaging technologists, nurses and research coordinators. The PET and MRI technologists have multiple roles, including, patient preparation and verification, safety screening, possible intravenous placement if exam requires, patient positioning on scanner, coil placement, image archiving and more. Cyclotron staff, radiochemists, and radiopharmacists may be present, depending on the ability of the imaging facility but will not interact with the patient. They work together to create and refine short & long-lived positron emitting radionuclides. Other possible interactions in the PET/MR department include radiologists, front desk staff, schedulers, maintenance and more.

CERTIFICATION REQUIRED

Required credentials are state dependent, and may vary state to state. Most states desire a certified Nuclear Medicine Technologist board certified by an accredited organization such as NMTCB and/or the ARRT (N). A licensed Nuclear Medicine Technologists is required to perform all injections of radiopharmaceuticals used in PET/MR exams. Dual licensed technologists are few in number but highly desired for some institutions. However, an MRI Registered Technologist by a recognized organization as the ARRT or ARMNIT for MR is also accepted for staffing. Dual or multi-modality credentials illustrate a detailed knowledge of both nuclear medicine and MRI. Understanding these distinct sciences are critical for effective workflows for PET/MR research and clinical care.

Licensed NM Physicians and/or Radiologists are required to interpret the studies and should be cross-trained in both modalities to allow better workflow. Dual reading for these types of studies are preferred but this decision is based on the institution and their confidence in the reader.

MRI SAFETY AND RADIATION SAFETY

Since PET/MR utilizes a 3 Tesla magnet, the same safety guidelines that apply to all conventional 3T magnets still apply to the hybrid PET/MR machine. Adhering to all MRI safety guidelines are essential in the PET/MR department and must be followed by all personnel and including patients. Four MRI exclusion zones are still implemented to reduce non-essential personnel from access to the PET/MR scanner room. MRI safety screening must be performed on all patients before entering the department and before any PET/MR exam can be performed safely. Unlike PET/CT, PET/MR does not incorporate ionizing radiation for image acquisition or AC map generation, and

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results in markedly reduced dose exposure to patients. However, all PET radiation guidelines still apply as positron emitting radionuclides are the crucial molecular imaging agents. References for MR safety guidance can be made with the American College of Radiology (ACR) White papers, titled, ACR Guidance Document on MR Safe Practices: Updates and Critical Information 2019.

**QUALITY ASSURANCE/ QUALITY CONTROL TESTING**

Quality assurance testing on the PET/MR scanner is based on the manufactures recommendations. Daily PET quality control (QC) testing is required before any patient acquisition is performed. A germanium-68 filled cylindrical source is used to perform the daily QC which is similar to what is currently done for PET/CT daily QC. ACR requires weekly ACR measurement but daily testing is based on the institution’s policy.

**WB VS REGIONAL**

Study protocols are not standardized. Each institution may have their own defined PET/MR protocols. Depending on the clinical indication or research goal, PET/MR can have a wide spectrum of detailed imaging protocols. The following is an example of what can be used for Wholebody vs. Regional PET/MR imaging. Many oncological based imaging sessions involve a Whole-Body or Skullbase to thighs PET/MR with follow up delayed regional PET/MR. Whole-Body PET/MR provides excellent discernment of metastatic cancerous tissue. The follow up Regional PET/MR normally follows a routine MR based regional protocol with delayed simultaneous PET collection. The smaller FOV Regional PET/MR utilizes thinner MR slice prescriptions than the Whole-Body data, which forwards detailed information about primary lesions. Regional protocols most often use gadolinium contrast enhancement for further soft tissue delineation. Neurology based PET/MR primarily involves the brain region, often with dynamic PET injections and simultaneous acquisition of MRI sequences with, if ordered, follow up MRI post contrast imaging. All protocols used in routine MRI can be linked to the PET and acquired simultaneously. There are some limitations however, regarding the type of coils used to acquire PET images. Some coils are attenuation corrected and can be used for PET and MRI imaging such as body matrix or head-neck coils. Coils that have not been attenuation corrected should be avoided for PET/MR acquisition, as if the coil is too thick it may create issues with PET imaging.

**CURRENT ISOTOPES BEING USED**


**PATIENT PREPARATION**

Patients are provided with instructions by a PET technologist and/ or nurse. These instructions include arrival time, fasting if required, information regarding what the patient may expect on the day of their exam and post-instructions if needed at the time. During this discussion, it is important that the patient is screened for any implants (safe or unsafe) and asked to provide any paperwork regarding the implant(s). A review of the patients’ medical history is also performed to ensure if any medications may need to be delayed or taken earlier. The NM Physician and/ or nurse may need to discuss further instructions for diabetic patients. Patients are notified that they will be expected to change into MRI safe gowns or scrubs for their exam. It is highly recommended that patients change into hospital provided MR-safe gowns or scrubs. Some clothing may contain metal lining not easily visible.